220

RESEARCH DEVELOPS NEW PRODUCTS FROM APPLES

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Apples are one of our largest domestic fruit crops. The average annual production in this country is more than 120 million bushels, or almost one bushel per capita. Of this total, 35 million bushels, or nearly 30 per cent of the annual crop, is ordinarily utilized in the manufacture of a wide variety of food and industrial products. Production of apple by-products by the leading States is shown in Table I.

One of the research projects of the Eastern Regional Research Laboratory is the development of new and improved products from apples. It should be emphasized at the outset that our research is not concerned with the better grades of apples, which normally find their way into channels of fresh fruit consumption. We are concerned with the utilization of low-grade or surplus fruit, which should be diverted from the fresh-fruit market. The extension and diversification of apple by-products helps to stabilize the demand for fresh market fruit, and to maintain its quality and price. A large by-products industry will increase the total demand for apple products and will act as a bulwark against seasons of over production or periods of economic depression.

The apple is a versatile fruit, and is becoming more so as a result of technical research. The accompanying chart shows nineteen products from apples, including two (dotted rectangles) which are not produced on a commercial scale. This list includes only primary products. Not listed are such secondary products as apple jelly, candy, pie, mincemeat, and

various products fortified by essence, all of which are derived from one or more primary products.

Apple product research in the United States Department of Agriculture has centered around a few main products: Juice, sirup, essence, frozen slices, pomace, pectin, and firmed apple slices. Let us consider each of these in detail.

Juice

A great tonnage of apples is ground and pressed, resulting in juice and pomace. The juice may be consumed fresh without further treatment, and the pomace is often discarded or fed to livestock. Sizeable industries have developed from the further treatment of the juice and the pomace. Some 4 to 6 million gallons of apple juice is canned or bottled annually in this country, and another 1.5 million gallons is produced in Canada.

The problem in processing juice is to preserve for a period of several months the "typical apple flavor" of the original juice. The quality of the product will depend to a large extent on the quality of the fruit used. It is impossible to make good juice from poor fruit. In general, a blend of several varieties is superior to juice from a single variety. One should attempt to produce a juice with an acidity of 0.5 to 0.6 per cent (calculated as malic acid). To attain the desired acidity, it is often necessary to include a "tart" variety in the blend. Some of the varieties commonly used in apple juice blends are Jonathan, Stayman Winesap, Baldwin, Red Delicious, McIntosh, and Northern Spy.

A persistent difficulty encountered in canning apple juice is the problem of sediment. The amount of sediment is greatest in centrifuged or filtered juice, but even juice clarified with Pectinol or gelatin will develop sediment on storage. The sediment which separates from cloudy juices on storage does not seem to be as objectionable nor as noticeable as the sediment which separates from clarified juices. Obviously it is most noticeable in glass containers. Some manufacturers use brown glass containers with large "wrap-around" labels to make the sediment less noticeable. Clarified juice, while having a more attractive appearance, usually has less flavor then centrifuged or filtered juice. In order to insure maximum flavor retention,

the juice should go from the press to the container with the minimum of delay.

An important recent development in apple juice manufacture is the addition of ascorbic acid. Although the use of this acid in apple juice dates back only three years, it has created widespread interest in this country. In Canada, during the last two years of the war, the fortification of apple juice with ascorbic acid was compulsory in order to provide a domestic source of vitamin C. In the United States much smaller quantities of ascorbic acid are added to apple juice, the purpose being to provide an anti-oxidant for improving stability of color and flavor.

Additional research is needed to determine how much benefit is obtained from addition of ascorbic acid and what types of juice products are benefited most. The problems of discoloration and sediment formation in juice also require further study. And finally, some method is needed for extracting apple juice by a continuous mechanical process which will require less labor and be more sanitary than the conventional hydraulic cider press using press cloths.

Apple Sirup

Various products of sirupy consistency are made from apple juice. They are distinguished as follows: If the juice is boiled down in an open vessel, the product obtained is boiled cider, which is rather dark and has a strong taste. If it is evaporated under vacuum, the product is called concentrated apple juice and is lighter in color and milder in flavor, although still sharply acid. If the acidity of the juice is removed or neutralized and the juice evaporated under vacuum, one of several types of apple sirup is produced.

Apple sirup made by the present commercial process, developed in the Eastern Regional Research Laboratory, is amber in color, very sweet, and bland. It has no distinctive flavor, not even that of apple, but it has a slightly bitter aftertaste, due to calcium malate. About 10 million pounds of sirup have been produced in this country and Canada during the past four years. The process in general is briefly outlined as follows: The apples are sorted, washed, and ground, and the juice is pressed out by a hydraulic press. The juice is treated

with a slurry of hydrated lime until the pH is 8.0 to 8.5, heated to 175 degrees F. (79 degrees C.) to precipitate the pectin, and filtered. The clarified juice from the filter press is acidified with dilute sulfuric acid (or other acid) to a pH of 5.0 to 5.5 and then evaporated under vacuum to a sirup containing approximately 75 per cent of solids. Its consistency is about that of an invert sugar sirup of the same solids content.

This apple sirup is the one used commercially for conditioning tobacco products. A better sirup, suitable for table sirup, is made by removing the acid instead of neutralizing it. The extracted juice before concentration is passed over a bed of anion exchange resin, which absorbs the malic acid. Malic acid would be a by-product of this process, once it is put into commercial operation.

Apple Essence

Apple essence is the volatile fraction of fresh apple juice which gives it its characteristic odor and aroma. It consists of a complex mixture of volatile acids, esters, and aldehydes. The total quantity of these substances in apple juice is about 30 to 40 parts per million. The essence is so volatile that it is completely lost in the preparation of apple butter, sirup, concentrate, and evaporated slices, and some is lost in such products as pasteurized juice, canned apples, and sauce.

Previous attempts to recover these flavors, made both in this country and in other countries during the past 20 years, had not been completely successful because either some of the more volatile components were lost or in the course of recovery the initial fresh flavor was altered. The process as developed at this Laboratory consists of three comparatively simple steps: (1) Rapid vaporization of 10 per cent of the juice, (2) mechanical separation of the vapors from the liquid, and (3) fractionation of the vapors to obtain a more concentrated flavor. It is important in stage (1) to reduce the period of heating to a minimum (fifteen seconds or less) to prevent change in flavor of the juice.

Apple essence prepared by the above process is a colorless water solution containing the volatile flavors in a 100- to 150-fold concentration. When a small amount of the essence is added to a good grade of apple concentrate and reconstitut-

ed with water, the product is distinguishable from fresh apple juice.

The essences from different varieties of apples vary in quality. Essence has been prepared from nine selected varieties. As might be expected, the character of the essence varies with the variety of apple from which it is produced. Such fragrant varieties as McIntosh and Delicious produce very fragrant essences.

Some of the products improved by the addition of apple essence are apple jelly, apple candy, and sauce. Apple concentrate fortified with essence could be used as a fountain drink or beverage. Other possible uses will be apparent to persons in the food industry. Although the process for manufacturing apple essence was developed less than three years ago, 14 companies in the United States and four in Canada are now equipped to manufacture this product on a commercial scale.

Frozen Apple Slices

In recent years a considerable volume of apples has been marketed as frozen slices. More than two million bushels of apples are used in this way each year. Frozen slices enable the pie baker to use suitable varieties in optimum condition throughout the year without varying his formula.

Various methods have been developed for preventing darkening of frozen slices. One of the most widely used methods is blanching, which destroys the enzyme responsible for discoloration. The disadvantages of blanching are that it softens the slices and causes loss of soluble nutrients. Current research studies may be able to overcome these objections to steam blanching.

Treating fresh slices with sulfur dioxide or bisulfite solutions also inhibits discoloration during freezing and storage. This method, widely used on the Pacific coast and in Canada, is described in Mimeograph AIC-57, "Commercial Preparation and Freezing Preservation of Sliced Apples," available at the Western Regional Research Laboratory, Albany, California. It is difficult to eliminate all the sulfur dioxide from the slices prior to baking and for that reason many States restrict the use of sulfured fruit.

A recent interesting development is the use of ascorbic acid to inhibit darkening of frozen slices. Although this method overcomes the principal objections to the blanching and sulfur treatments, it is expensive and difficult to apply. Considerable difficulty is experienced with inadequate penetration of the treating solution. The ascorbic acid method has several distinct advantages, however, and research on this process may enable it to be used commercially in the near future.

Firmed Apple Slices

Apple pie is, or should be, America's Number 1 dessert. Millions of bushels of apples are used in baking pies, and probably many more millions of bushels would be used in this manner if it were possible to combine firmness and flavor in the apples used for pie baking. At present the requirement for firm apple slices limits the baker's choice to a few winter varieties. Flavor is a secondary consideration.

Within the past year studies conducted at the Massachusetts State College and at this Laboratory have resulted in the development of procedures for improving the firmness of apple slices. Such firmed slices may be used for canning, freezing, or pie baking. The results to date indicate that any variety may be firmed sufficiently for processing. The inherent softness of a particular apple variety need not limit its use for canning, freezing, or baking. This should provide a profitable outlet for millions of bushels of McIntosh, Gravenstein, and other "soft" varieties which are usually classified as unsuitable for processing in this way. Most of the apples produced in New England (Table II) are considered to be too soft for processing.

Apple slices may be firmed prior to canning, freezing, or baking by treating them with a solution of calcium chloride. The latter may be applied in various ways such as dipping, impregnating, or cooking the slices in the solution. The concentration of calcium chloride required to firm the slices may range from 0.1 to 1.0 per cent, depending on the variety, degree of maturity, method of application and firmness desired.

We have studied the effect of calcium chloride on the following summer and early fall varieties: Yellow Transparent, Williams Red, Rambo, Starr, Gravenstein, Smokehouse, Mc-

Intosh, Wealthy, and Jonathan. In each case the untreated slices made very poor pies, a high proportion of slices showing fractures or complete disintegration to a saucelike consistency. The calcium-firmed slices made pies of excellent texture and firmness. We consider the desired baked apple slice to be one that holds its shape, showing no fractures or ragged surfaces, and having a uniform firmness comparable with that of a ripe banana. We have been able to prepare slices with adequate firmness from each of the above-listed varieties and have every reason to believe that the calcium-firming method will give satisfactory results with any other variety and can be used on fruit at nearly any stage of maturity.

Considerable study has been devoted to developing simplified procedures for firming apple slices on a commercial scale. Fresh apple slices (for pie baking) may be firmed by dipping in a calcium chloride solution. More uniform firming is usually obtained by vacuumizing the slices and impregnating them with a calcium chloride solution. This method requires special equipment and additional labor but gives an excellent product. Canned slices and frozen (blanched) slices may be firmed with little change in the usual commercial procedures. For example, blanched slices may be firmed by dipping in a calcium chloride solution prior to packaging and freezing.

Owing to the widespread interest in the problem of firming apple slices, this project has developed rapidly from the laboratory stage to actual commercial utilization. Already several companies have made commercial trials on calcium-firmed slices for canning and freezing. One mid-western apple processor recently packed one thousand 30-lb. cans of calcium-firmed McIntosh slices. These apples had been kept in common storage until late October and were fully ripe and well flavored.

This points to a second advantage of firmed slices, namely, the fact that apples may be used at a fully ripe stage, thereby achieving the maximum in flavor. The New England apple grower and processor should have a very real interest in firmed apple slices, because more than 50 per cent of the apples grown in their area are McIntosh, a variety having excellent flavor but lacking in firmness.

Pomace

In the manufacture of nearly all apple products, except apple butter, a large proportion of the apple is left as peels and cores or as crushed whole pulp. These residues may be dried and used for pectin manufacture or for cattle feed. Obviously, dried pomace brings a higher price when sold for pectin manufacture. Our Laboratory is studying factors affecting the quality of commercial pomace in an effort to improve methods of preserving pectin value. We have tried to emphasize the need for determining the pectin grade of dried pomace as a means of controlling the quality, and also for the purpose of segregating pomace into a pectin grade and a feed grade. The pectin grade could then be sold at a premium, and the lower quality pomace used for feed.

Some of the factors which probably affect the pectin grade of pomace are variety, maturity, proportion of peels and cores, method of drying, and method of handling prior to drying. There is very little that one can do about variation caused by variety, maturity, or proportion of peels and cores except to use such information as a rough guide to determine the expected quality. The method of drying does not appear to affect the quality to any appreciable extent, provided the drying is done promptly and the pomace is not scorched. The time between pressing and drying should be as short as possible because long delays reduce the pectin value of the pomace. Mechanical types of driers are replacing kiln driers in many localities, thus reducing labor costs.

Pectins

Pectin has been used by housewives and commercial jelly manufacturers for many years. To the chemist pectin is a highly-esterified polygalacturonide, but to the trade it is just pectin. It forms a firm jelly when used in a fruit juice containing 65 per cent of sugar. Within recent years another type of pectin, called low-ester pectin, has been developed. It differs from the older type in that, if a little calcium is available in the juice, a jelly will form without the addition of sugar. With this modified pectin, jellied fruit desserts and aspics can be made with a small proportion of sugar, or none at all.

Jellies made with 35 to 45 per cent of sugar have more of

the natural fruit flavor than those made with the customary 65 per cent but are not self-preserving. A 65-per-cent-sugar jelly is relatively self-preserving, in that micro-organisms grow slowly or not at all in it, whereas a jelly with less sugar must be packed sterile, and after opening must be kept under refrigeration or consumed within a few days. During the war the Army used nearly 20 million 4-ounce cans of jellied fruit dessert made with low-ester pectin. The product was sterilized in the can in the conventional manner, and was convenient to open and serve in the field. Several large food organizations are interested in the manufacture of various desserts and other jellied products with low-ester pectin. Such products may soon replace or supplement many of our present jellied foods.

What of the Future?

The extent of recent progress in the field of apple by-products is best emphasized by pointing out that eight new products have been added since 1920. Between 1930 and 1940 such new products as nuggets, frozen slices, low-ester pectin, and pasteurized juice were developed. Since 1940, sirup and essence have been added to the list. This year will see the commercial production of firmed apple slices for the first time. We are not betting as yet on the commercial possibilities of malic acid or wax. With the intensified research on apple products, it is reasonable to expect the development of many new products from apples.

TABLE I
UTILIZATION OF COMMERCIAL APPLE PRODUCTION
Crop of 1944

Data from

Bureau of Agricultural Economics
U. S. Department of Agriculture

State	Total Production Commercial	Canned	Dried	Frozen	Other*	Total Processed	
	1000 bu.	1000 bu.	1000 bu.	1000 bu.	1000 bu.	1000 bu.	Per cent
New England States	6,741	24			948	972	14.4
New York	17,010	1,736	437	571	3,961	6,705	39.4
Pennsylvania	9,100	2,360	50	300	1,390	4,150	45.6
Virginia	14,580	2,067	508	213	3,159	5,947	40.8
West Virginia	4,356	862	90	60	1,161	2,173	49.9
Michigan	7,625	316		259	1,625	2,200	28.9
Washington	31,100	710	3,822	322	446	5,300	17.0
Oregon	3,432	322		118	409	849	24.7
California	6,144	288	1,867	375	660	3,190	51.9
Other States	24,666	638	121	207	3,023	3,989	16.2
TOTAL (35 States)	124,754	9,023	6,895	2,425	16,782	35,425	28.4

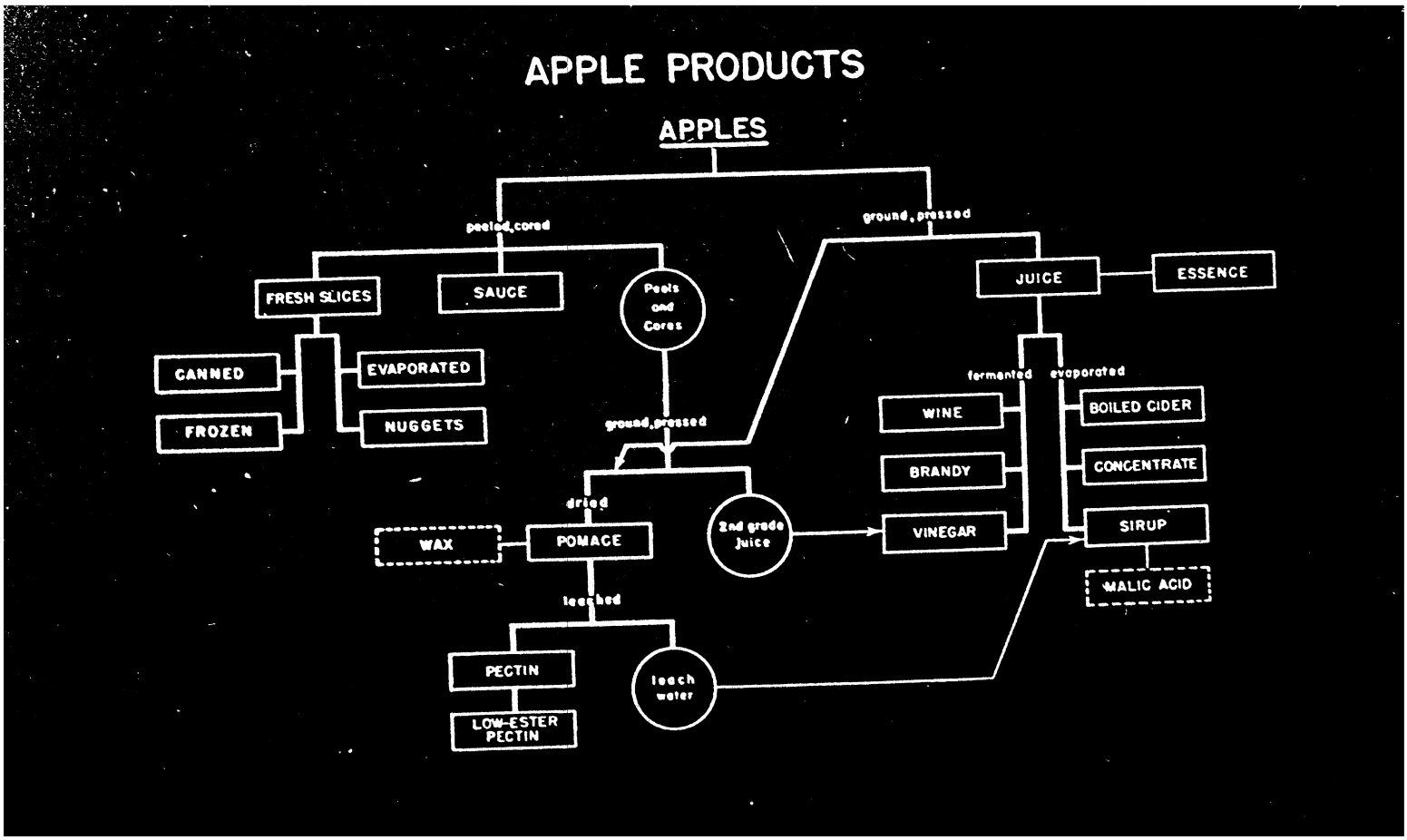
* Mostly fruit crushed for vinegar, cider, and juice.

TABLE II
NEW ENGLAND COMMERCIAL APPLE CROP, 1944
BY VARIETIES

Data from

Bureau of Agricultural Economics
U. S. Department of Agriculture

Variety	Production	Per cent of Total
	1000 bu.	
McIntosh	3,707	55.0
Baldwin	1,187	17.7
Delicious	421	6.2
Cortland	256	3.8
Northern Spy	237	3.5
Wealthy	147	2.2
Gravenstein	144	2.1
Rhode Island Greening	109	1.6
All Others	533	7.9
Total	6,741	100.0


APPLE PRODUCTS
APPLES
peeled, cored
ground, pressed
FRESH SLICES
SAUCE
Peels and Cores
JUICE
ESSENCE
CANNED
FROZEN
EVAPORATED
NUGGETS
fermented
evaporated
WINE
BRANDY
VINEGAR
BOILED CIDER
CONCENTRATE
SIRUP
MALIC ACID
ground, pressed
dried
WAX
POMACE
2nd grade juice
leached
PECTIN
LOW-ESTER PECTIN
leach water